Chapter Eighteen
Determining Probability

"I hate probability!" It would be hard to find a high school student who has not, at one time or other, uttered these three little words. And we admit that probability can be a daunting topic. Chapters eighteen, nineteen, and twenty will cover different aspects of probability, and we will try to make the topic as easy as possible.

There is one basic set of facts to know right at the start of the discussion of probability. The greatest possible probability value is 1, which means an event **must** happen. The smallest possible probability value is 0, which means an event **cannot** happen. Most of the time probability is expressed as a proper fraction or a decimal—a value between 0 and 1.

Let's illustrate these three statements: The probability of a baby zebra being male is $\frac{1}{2}$ (or 0.5). The probability of a baby zebra being female is $\frac{1}{2}$ (or 0.5). The probability of a baby zebra being either male or female is 1—it must happen. The probability of a baby zebra being neither male nor female is 0—it cannot happen.

There is an extension of the fact that a probability of 1 means that an event must happen. In any given situation, the sum of all the related probabilities must add up to 1. This means that if the probability that an event will occur is $\frac{1}{4}$, then the probability that that event will not occur is $\frac{3}{4}$: $\frac{1}{4}+\frac{3}{4}=1$. In a bowl containing green marbles and other colored marbles, if the probability of choosing a green marble is $\frac{5}{17}$, then the probability of choosing a different color marble is $\frac{12}{1}$: $\frac{5}{1}+\frac{12}{1}=1$. Did you notice that these alternate probabilities are easy to calculate? The sum of the numerators must always add up to the denominator.

A probability fraction is created by placing in the denominator the total number of options for a given situation, and by placing in the numerator the number of options in that given situation which satisfy some particular condition. (We will always assume that each of these options is equally likely to happen.)

Think back to that baby zebra. There are 2 gender options for that baby zebra—male or female—so the denominator of the probability fraction is 2. The probability of the baby zebra being male is $\frac{1}{2}$, because there is only 1 way in which being male can occur (and we are assuming that a baby zebra is just as likely to be male as female). The probability of the baby zebra being female is also $\frac{1}{2}$, because there is only 1 way in which being female can occur. In each of these cases, the numerator of the probability fraction has the value 1.

These are the basic facts about determining probabilities, but there are other facts we will also need to know. When two situations are involved at the same time, the rule we must know is that when the problem says "and" you will multiply the two probabilities, and when the problem says "or" you will add the two probabilities.

If the probability of spinning a "3" on a game wheel is $\frac{1}{5}$ and the probability of spinning a "yellow" on a second wheel is $\frac{1}{3}$, then the probability of spinning a "3" and a "yellow" is $\left(\frac{1}{5}\right)+\left(\frac{1}{3}\right)=\frac{1}{15}$, but the probability of spinning a "3" or a

"yellow" is $\left(\frac{1}{5}\right)+\left(\frac{1}{3}\right)=\frac{8}{15}$. When the words of the problem said "and," we multiplied the two probability fractions, and when the words of the problem said "or" we added the two probability fractions.

Here is a more important fact. The probability of an event does not change, regardless of how many times something has already happened. Consider the baby zebra again. The probability of a baby zebra being male is $\frac{1}{2}$. If 5 male baby zebras have already been born, what is the probability that the sixth baby zebra will also be a male? The answer is still $\frac{1}{2}$. The probability does not change, regardless of how many times something has already happened. (This answer would still be $\frac{1}{2}$, even if the first 5 baby zebras were female.)

One reason that so many students dislike the topic of probability is the great variety in the types of word problems, and the many different ways in which the questions can be asked. There is no easy way around this. Just keep in mind what has been said so far in this chapter. To help you, here is a brief summary:

1. The greatest probability value is 1—an event must happen. The least probability value is 0—an event cannot happen.
2. Most of the time, probability is a fraction (or a decimal). The denominator of the fraction is the total number of possible occurrences in the situation. The numerator of the fraction is the number of occurrences that satisfy the conditions described in the problem.
3. The sum of all the related probabilities in a given situation is always 1.
4. When a word problem with two probability values says "and," you should multiply the two probability values. When a word problem with two probability values says "or," you should add the two probability values. (We will talk more about the "and" situation in chapter twenty, The Counting Principle. Therefore, there will be no practice problems of that type in this chapter.)